Consultative Committee for Space Data Systems

REPORT CONCERNING SPACE DATA SYSTEM STANDARDS

INTRODUCTION TO CCSDS CROSS SUPPORT

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GREEN BOOK

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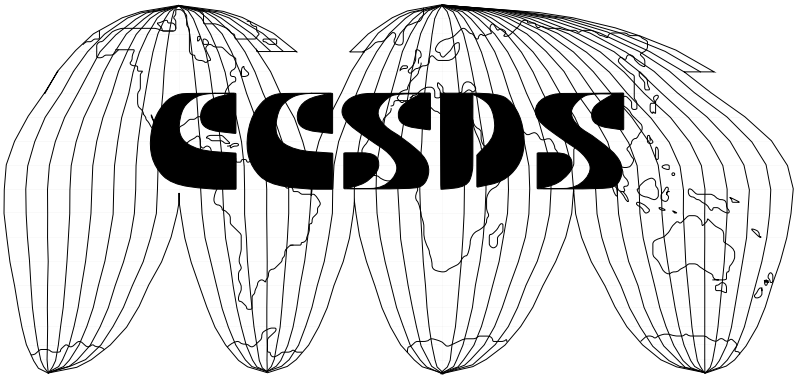

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FOREWORD

The Consultative Committee for Space Data Systems (CCSDS) is an international organization officially established by the management of multiple space agencies. Its charter is to facilitate interoperability between space agencies through the development of data handling techniques for spacecraft operations, space research and space science applications.

To realize the maximum benefit, agencies voluntarily implement internal standards consistent with CCSDS recommendations. This allows increased mission benefits from a growing capability to provide inter-agency cross support. Specific instances of cross support for a particular mission is based on multi-agency agreements specific to that mission.

The ensuing capabilities for providing cross support and sharing expensive ground- and space-based facilities on an international basis enables greater flexibility in individual agency mission planning and facilitates integration of international payloads and missions.

CCSDS recommendations are intended to complement, not compete with, other international standards. Other international standards are utilized where applicable, while CCSDS activities are focused on system aspects unique to space data systems.

This document serves as an introduction to the CCSDS cross support concept.

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1 INTRODUCTION

1.1 Purpose

This document serves as a description of the Consultative Committee for Space Data Systems (CCSDS) cross support concept. Significant economic and programmatic benefits are realized by spacecraft managers, mission operators and scientists who adopt the CCSDS concept and implement their data transport and interpretation systems accordingly. This document summarizes the technical and operational considerations of cross support of such Space Data Systems (SDS). These cross support considerations are presented in more detail in the *CCSDS Cross Support System Description* Green Book - Vol.1.

1.2 Statement of the Problem

A major portion of space related activities involves the interchange of information among users. As shown in Figure 1-1, Space Data Systems Overview, CCSDS agencies implement and operate extensive space and ground data systems in support of this information interchange process.

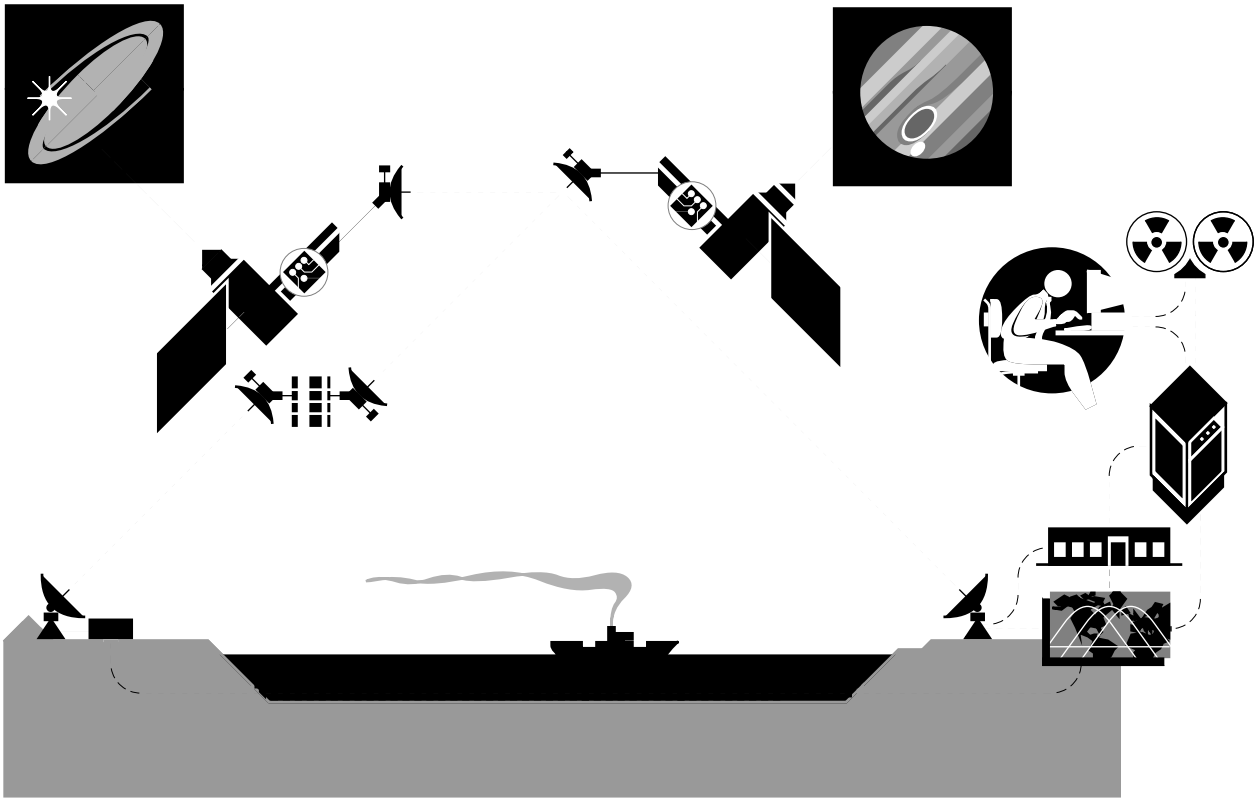

Figure 1-1 Space Data System Overview

Information is acquired from remote sensors observing some phenomenon under investigation. This information is then transported to and across the Earth to its designated destination. It is processed by, and exchanged among, various users and stored in data archives for subsequent reuse. These data systems must meet many and varied requirements, including diversity of users, a wide range of data types and data rates and different needs for information about the data.

There are substantial costs associated with the implementation and operation of the data systems to meet these requirements. A significant portion of these costs are associated with frequent design and development of customized systems. As the demands placed upon such data and information systems increase, system cost reduction measures assume greater importance. One viable approach to the reduction of such costs is the development of standard methods of performing routine tasks.

1.3 Background

In 1982, many of the world's space agencies formed an international committee to discuss common problems relative to the development of space data systems. It was realized that the growing complexity of space missions, as well as their associated costs, could adversely impact space endeavors in the future. Therefore, CCSDS was established to address these concerns.

CCSDS, through the collective efforts of its international experts, performs end-to-end systems analyses and adopts or develops standard approaches for solving these routine problems. After these approaches have been reviewed and officially accepted by the CCSDS member agencies, they are issued as CCSDS Recommendations. Agencies are increasingly adopting CCSDS Recommendations for a growing number of space missions and implementing their data systems accordingly.

1.4 Cross Support Concept

As CCSDS Recommendations are adopted and implemented by space agencies, compatible support capabilities are developed in those agencies. It is then possible for agencies to share more easily and with less cost, the resources which have been established to acquire data from remote sensors, to transport this information to designated destinations, to process their data for various purposes and to store the data for future reuse. The term Cross Support is applied when one agency uses part of another agency's data system resources to complement its own system. Cross support can be beneficial for many reasons, including:

- technical: to attain additional network coverage or to conduct some programmatic endeavor like Very Long Baseline Interferometry measurements,
- economic: to avoid the expense of duplicate implementation, especially to meet some short term requirement,
- emergency: to increase mission support over that normally planned, and
- research: to avoid the cost and time delay of repeating investigations or reflying an experiment and to obtain unique data acquired in the past and held by another agency.

The objective of CCSDS activity is to facilitate cross support, thereby maximizing the performance and cost benefits to be gained.

2 THE CCSDS DOMAIN OF INTEREST

In the CCSDS Domain of Interest, there are many and diverse users of the information interchange process, including scientists, operators, data base managers, data archives, mission control centers, instruments and spacecraft. The information interchange may take place in real time, as is the case during mission operations, or it may involve the retrieval and reuse of very old data as may be the case in conducting correlative research.

2.1 The Space Data System Model

The generic data flow within a given agency's data system and a representative set of points at which information interchange between agencies may occur are shown in Figure 2-1.

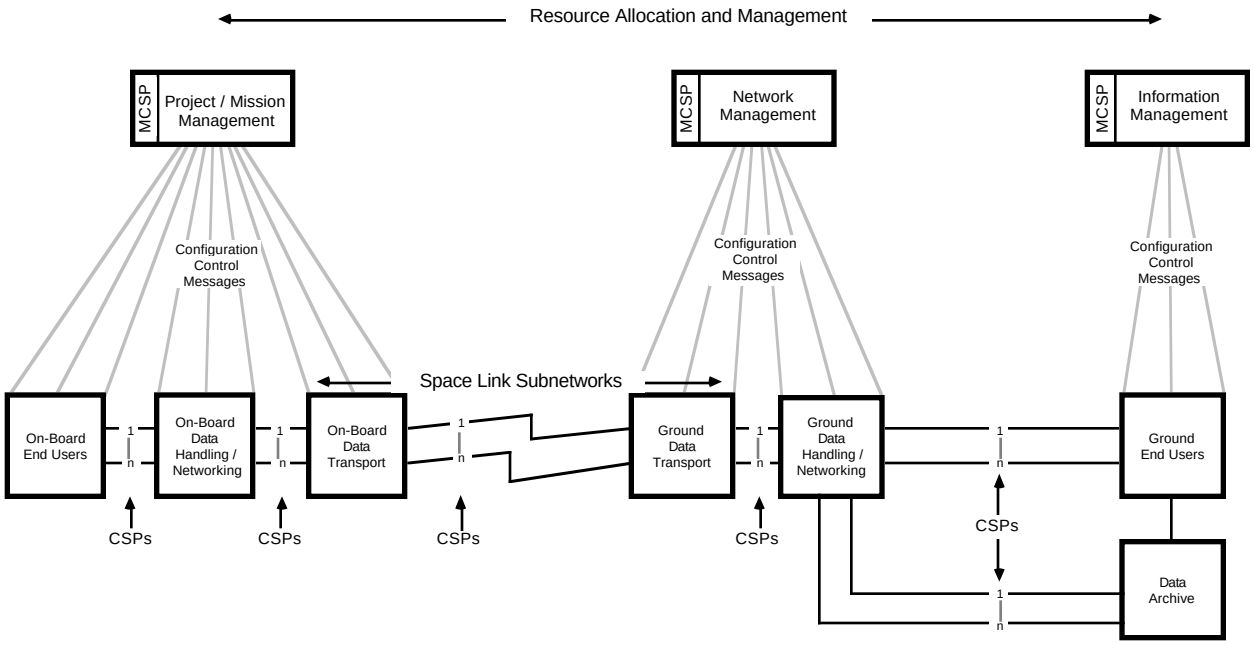

Figure 2-1 Space Data System Model

At this high level of abstraction, three major considerations attend the information acquisition, transport, processing and storage process:

1) Transporting data: The data exists at a location which is different from that at which it is wanted or needed; therefore, some system is required to transport the data between these locations.

2) Interpreting data: The data may be formatted in a manner which is unknown to the requestor; therefore some system is required to assist the requestor in interpreting the data.

3) Allocation and Management of Resources: In some instances, the resources of the systems which are supporting the interchange process may have limited availability; therefore some method is required whereby these resources can be properly allocated and managed for maximum effectiveness

Although each of these three considerations will be discussed in more detail in subsequent sections of this document, they are briefly introduced here.

Data transport, the first consideration, is addressed by the series of subsystems shown at the bottom of the figure. These subsystems, both in space and on ground, are aggregated together to form a Data Transport System (DTS). The DTS is a bi-directional system, moving data from source to destination in accordance with operational and research requirements. This system is called a Data Transport System because it transports the data without being involved in any way with the content or format of the message being transported. Note that Ground Networking includes both operational and non-operational functions. It is also important to note that the DTS does not have to be an electronic network. When time is not a critical factor, data can be moved by shipment of optical disks, magnetic tape or other physical media.

Data interpretation, the second consideration, is predominantly a function of the ground end users shown at the bottom right of the figure. In this context, a ground end user may be, for example, a spacecraft controller, a scientist or a facility which generates or receives data in real-time or non-real-time. At one time they can be involved with research activity being conducted during mission operations. At a different time, they may participate in correlative research activity independent of any mission operations. On these occasions, they assist in interpreting data which is unfamiliar to the researcher. This system is titled the Data Interpretation System (DIS) since it is concerned with recovering the information content from the data. The DIS may operate in a real or near real time mode. Data which is many years old may be requested from data repositories and the DIS must be able to assist in its interpretation.

The Allocation and Management of Resources, the third consideration, is represented by three entities in the middle of the figure. It includes negotiating the allocation of resources to develop an operations sequence of events, monitoring system performance to ensure that requirements are being satisfied, and renegotiating resource allocation as necessary.

2.2 Cross Support Points

A Cross Support Point (CSP) is defined as the point at which a CCSDS User agency may obtain from a CCSDS Provider agency those services required to accomplish an operational or research endeavor. They are represented in Figure 2-1 as the lines which join the subsystems of the SDS. "1....n" at each CSP represents different levels or types of services.

2.3 Concept of Services

In the CCSDS context, a service can be defined as the external appearance of functions and capabilities made available by a providing agency to a requesting agency. The essential feature is that a detailed knowledge of the internal mechanics of the providing agency is not necessary by the requesting agency.

The requesting agency need only concern itself with the agreed upon (prescribed) conventions at the interface between the two systems.

Services provided at CSPs will typically include not only the physical means for routing CCSDS-compatible data between agencies, but also the necessary technical and administrative resources required to set up and execute the transfer.

After high level negotiations between an agency wishing to receive cross support from another agency or agencies, the Management Cross Support Points (MCSP) shown in Figure 2-1 provide the first points of technical contact at which arrangements can be made to provide the requested services. The activities at the MCSPs are discussed in more detail in Section 5.

3 CROSS SUPPORT OF MISSION OPERATIONS

In Mission Operations, the assumption is made that information must be interchanged in real or near real time. This is achieved via the DTS which is composed of those supporting resource elements, both onboard and on the ground, which are aggregated together and configured so as to form a communications system linking the onboard instrumentation with the data reception centers on ground.

Each CCSDS member agency's DTS will contain one or more CSPs through which a user agency may obtain services to achieve some operational goal. These CSPs, as indicated in Figure 2-1, for example, may:

- connect an experiment to a Provider spacecraft and utilize the complete set of services offered by that spacecraft,
- connect a payload to a Provider spacecraft and utilize only part of the spacecraft services,
- "connect" a spacecraft to a Provider network and elect to receive services via the Space to Ground Link,
- connect a portion of its Ground System to the Provider's Ground System and utilize one or more of its services.

In addition to mission operations support, the Data Transport System can also be used to support missions during the launch phase. It enables the user Control Center to perform the necessary Telecommand, Tracking, and Telemetry functions. It also may carry appropriate management and signalling messages which monitor and control the DTS itself.

Mission operations may also use the services of the DIS for interchange of information dealing with operations. Not all DIS services are applicable. Examples of some DIS services useful for cross support are:

- Organization of the information into grouped data objects containing self-identified main information of interest and other data about the main information (eg. command transmit time, retransmission protocol to use, timer settings, etc.).
- Use of registered, common data dictionaries for common semantic understanding of parameters to be exchanged.
- Use of registered, common data interchange formats and languages.

4 CROSS SUPPORT OF RESEARCH

In the past, space missions and their associated SDS were designed in an environment composed of a small and well-defined group of users whose requirements must be satisfied. However, in modern and future long-lived missions, as well as in designing generic data systems, this assumption is not valid. For example, in cross support of research, a user agency or researcher is given access to data originally generated or archived by a Provider agency. The provider's database had not been developed for this user. To support research within the science community, users must be able to exchange data with other users who are separated by time as well as location. It may not be possible for the requestor to have direct access to the originator of the data. As an example, an experimenter might wish to review information from a previous mission with which he/she had no involvement. The DIS must offer, at a minimum, the following:

- Directory and catalog services to determine the existence and location of information
- Data Retrieval service to provide information access and retrieval
- Dictionary and Data Description service to assist in information interpretation

In a logical sense, the DIS offers these services at various CSPs within the SDS. The components of the DIS include such functions as parsing software, data interchange languages, and data definition languages.

Another component is a Control Authority which has the responsibility for maintaining and disseminating registered information about data resources. These resource packages are prepared by the data producer and contain semantic, syntactic and other supporting information about the data which are necessary for the recipient to understand the received data.

The DIS assists a researcher in determining what information exists as well as examining its relevance as he plans a research endeavor.

Where appropriate, the DTS provides the capability to support the functions of the DIS.

5 RESOURCE ALLOCATION FOR CROSS SUPPORT

To support many missions, it is necessary to negotiate for SDS resources. Support resources must be allocated to provide the requested services in accordance with time requirements. An example would be an operations sequence of events in support of a single, or series of, observing sequences. Reaching agreement on an operations sequence requires coordination among the managers who have authority over the several subsystems which collectively compose an agency's SDS.

In a cross support situation, each agency will have identified MCSPs through which the management entities of external agencies must negotiate. To gain access to another agency's SDS, it is necessary to negotiate at the appropriate MCSPs. (Negotiation for resources inside of an agency does not necessarily require interaction with the MCSP.) The MCSPs collectively compile and analyze the mission requirements, the science objectives and the network constraints and attempt to establish a satisfactory operations sequence of events. Developing a satisfactory operations schedule is an iterative process with a "best" solution sought which serves mission and science needs while not exceeding network constraints. Once each operations sequence is resolved, it is the responsibility of each MCSP to provide the resources as agreed.

The operations sequence of events is translated into a series of control messages as necessary to reconfigure relevant parts of the SDS. These control messages are normally passed in the form of tables which change switch settings and other parameters within the SDS in accordance with mission requirements for a particular epoch of the operations sequence of events. Although CCSDS will provide recommendations on the access procedures for MCSPs, no attempt will be made to standardize the internal control messages resulting from the procedures.

The mechanisms for managing the SDS are actually the policies and procedures by which multi-agency supporting resources can be aggregated and configured into a single virtual support network in a given cross support environment. During the development of the operations sequence of events, this consists mainly of the generation of, and response to, requests for CCSDS-identified support services.

Annex A

ACRONYMS

ACRONYMS

CCSDS	Consultative Commitee for Space Data Systems
CSP	Cross Support Point
DIS	Data Interpretation System
DTS	Data Transport System
MCSP	Management Cross Support Point
SDS	Space Data System